WE-H-2 — SAN

SHORT TITLE: WE-H-2-SAN

ATOMIC WEAPONS EMPLOYMENT HANDBOOK (U)

Sanitized Version

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SPECIAL WEAPONS TRAINING GROUP
FIELD COMMAND, AFSWP
SANDIA BASE, ALBUQUERQUE, NEW MEXICO

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HEADQUARTERS FIELD COMMAND
ARMED FORCES SPECIAL WEAPONS PROJECT
SANDIA BASE, ALBUQUERQUE, NEW MEXICO

FOREWORD

This publication has been prepared by the Weapons Employment Branch, Orientation and Employment Division of Special Weapons Training Group, Field Command, Armed Forces Special Weapons Project. It is intended for use by the Military Services in the field of weapons employment and as a teaching vehicle in courses conducted by the Special Weapons Training Group.

Included in this handbook are isodamage curves for a variety of targets, data enabling the user to predict the levels of various weapons effects, and mathematical tools which the trained employment analyst can use to solve the target analysis problem.

The reference source for material dealing with damage to various types of targets and for data pertaining to weapons effects is: Capabilities of Atomic Weapons (U), TM 23-200; OPNAV INSTRUCTION 03400.1B; NAVMC 1104 Rev, revised edition November 1957; Nuclear Radiation Handbook (AFSWP-1100); Prediction of Neutron-Induced Activity in Soils (AFSWP-518); and the Thermal Data Handbook (AFSWP-700).

Material concerned primarily with the analysis problem has been drawn from various sources, primarily from publications of Sandia Corporation and previous publications of the Weapons Employment Branch, Orientation and Employment Division. The Sandia Method of Weapons Employment Analysis described in this publication is presented as a teaching vehicle. The step-by-step numerical approach to answers is intended to train the analyst in the mental processes which in operational analysis problems may be applied in the form of judgment. Familiarization with the theory and the procedures performed in the Sandia Method will also enable the analyst to increase his understanding of the various effects parameters and thus may improve the basis for his judgment in employing services operational target analysis methods.

This handbook is not intended to be an exhaustive source of effects and damage information. Rather, it is a compilation of information of most immediate interest to the weapons employment analyst, who is assumed to be fully trained and qualified in the interpretation of the data and in the technical aspects of weapons employment.

Users of this publication are invited to report any errors, discrepancies, or omissions they may find. Suggestions for the improvement of future editions will be welcomed.

FOR THE COMMANDER:

S. K. Yarbrough

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Colonel GS
Deputy Chief of Staff
Special Weapons Training

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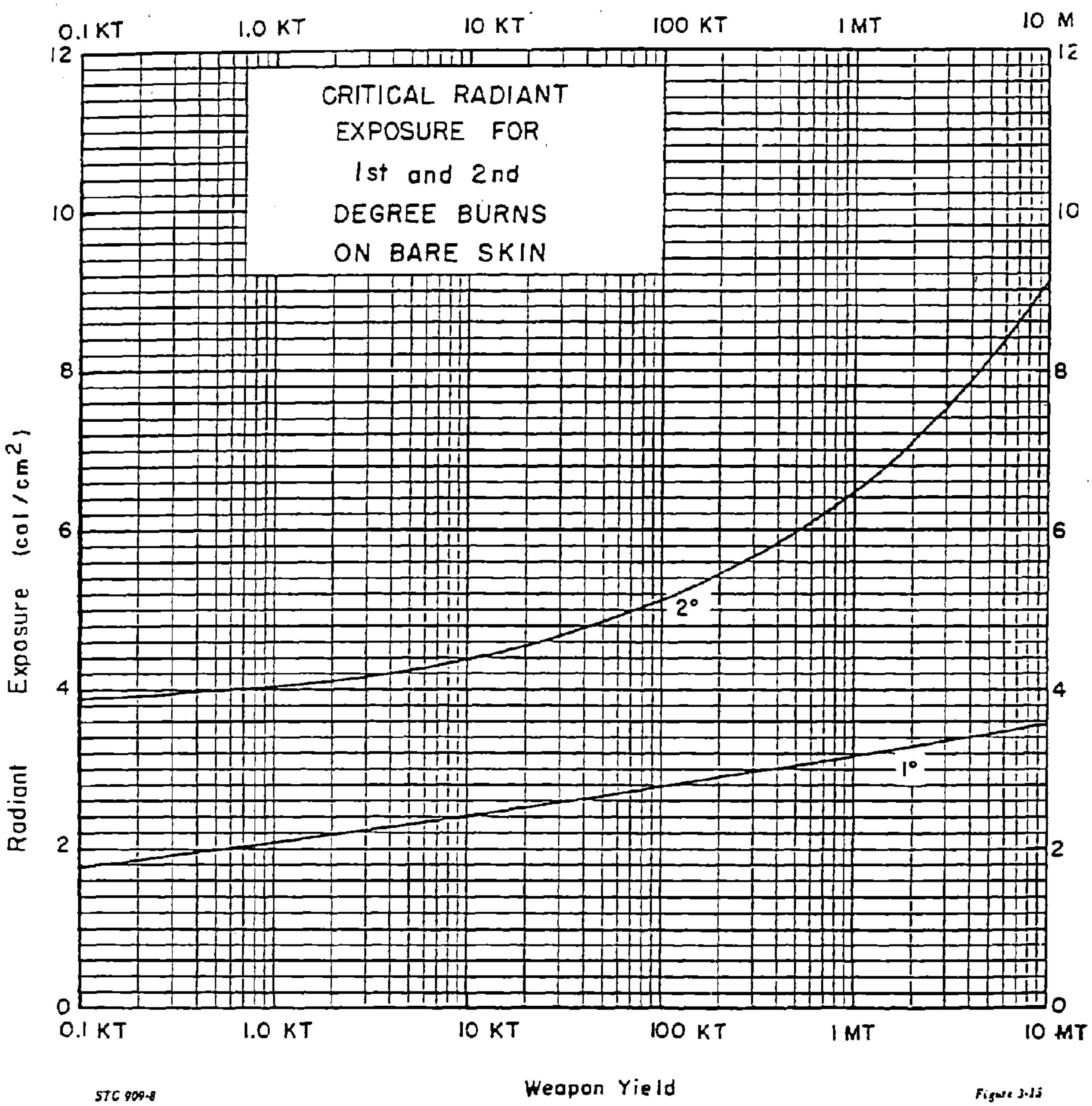

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Figure 3-15

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3-5.9 MISCELLANEOUS THERMAL RADIATION CRITERIA.

3-5.9.1 GENERAL. The employment of atomic weapons over metropolitan, urban, or forest areas may produce in addition to blast damage, mass fires which under the proper conditions materially increase the degree and extent of damage.

3-5.9.2 URBAN FIRES. A survey of metropolitan areas of the United States indicates that of the exterior kindling fuels present, newspapers and other paper products account for 70 percent of the total, while dry grass and leaves account for another 10 percent in residential areas. Most other exterior kindling fuels are present in small percentages or require radiant exposures in excess of 10 cal/cm^2 for ignition. Since paper is the major exterior kindling fuel and is also an important interior fuel, the extent of ignitions may be estimated from the minimum radiant exposure requirements for this material, figure 3-16. The thermal charts, figures 3-9 through 3-14, give distances to which the required calories will extend. To estimate the burning potential of the area under consideration, figures 3-17 and 3-18 may be used.

3-5.9.3 DEFINITIONS OF BURNING POTENTIAL. (See figures 3-17 and 3-18.)

a. Low: Slow-burning fires. Fire can be controlled at will. Control action can be on unit structure basis.

b. Dangerous: Fires burn rapidly. Individual building fires combine to form an area fire. Organized action needed to confine fire to area originally ignited.

c. Critical: Rapid build-up conflagration-type fires. High probability of fire storm, with frequent and severe spotting. Requires evacuation of fire-fighting equipment and personnel. Control action effective only at critical breaks in building continuity or density.

3-5.9.4 RELIABILITY. This is based upon limited empirical data.

3-5.9.5 ILLUSTRATIVE EXAMPLE.

1. *GIVEN:*

a. A 100 KT weapon.
b. A relative humidity of 40 percent.

2. *REQUIREMENT:*

Find the minimum radiant exposure required for the ignition of newspaper.

3. *SOLUTION:*

a. Enter the Newspaper Ignition chart on the bottom margin with a relative humidity of 40 percent.

b. Read up this line to the intersection with the 100 KT curve.

c. Read to the left-hand margin where a minimum radiant exposure of 5.1 cal/cm^2 is read.

4. *ANSWER:*

Minimum radiant exposure for the ignition of newspapers is 5.1 cal/cm^2.

3-5.9.6 FOREST FIRES. The fire potential in a forest area is dependent upon the type of kindling fuels present on the forest floor, recent and present weather, and present wind conditions, among other considerations. Table XIII below gives a defintion of the types of kindling fuels which might be encountered. By determining the type of kindling fuel, one can determine the calories required to ignite a forest by referring to figure 3-19. The thermal charts, figures 3-9 through 3-14, give the distance to which the required number of calories will extend, thus giving an estimate of the distance or area where one might expect to start forest fires. Taking into account present weather conditions and wind speeds, table XIV gives an estimate of the type of fire that will result. See paragraph 6-11.3 for an illustrative problem.

3-5.9.7 SCALING. To find minimum radiant exposures for yields other than 1 KT, multiply the exposures read from figure 3-19 by $W^{1/8}$.

3-5.9.8 RELIABILITY. Based upon observed results of limited full-scale tests and extensive laboratory experiments. The results are not considered reliable in the megaton range.

TABLE XIII. CLASSES OF THIN WILDLAND KINDLING FUELS (ARRANGED IN ORDER OF DECREASING FLAMMABILITY)

Class	Description
I	Broadleaf and coniferous litter-mixture of fine grass, broken leaves and duff, and thin translucent broadleaf leaves.
II	Hardwood and softwood punk in various stages of decay.
III	Cured or dead grass.
IV	Conifer needles and thick, nearly opaque broadleaf leaves.

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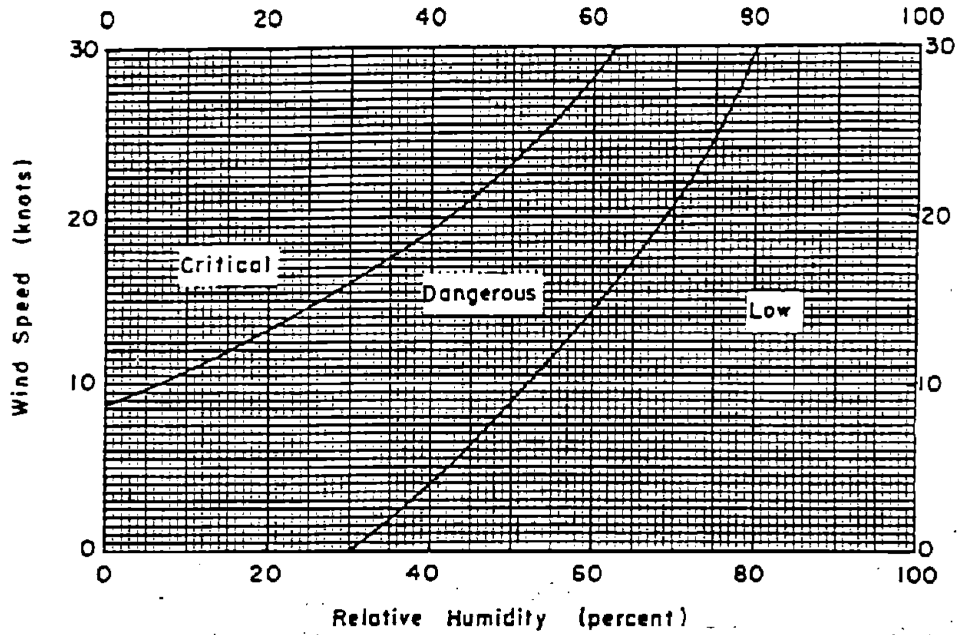

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Figure 3-17. Burning Potential for Urban Areas (Central Heating Not in Use)

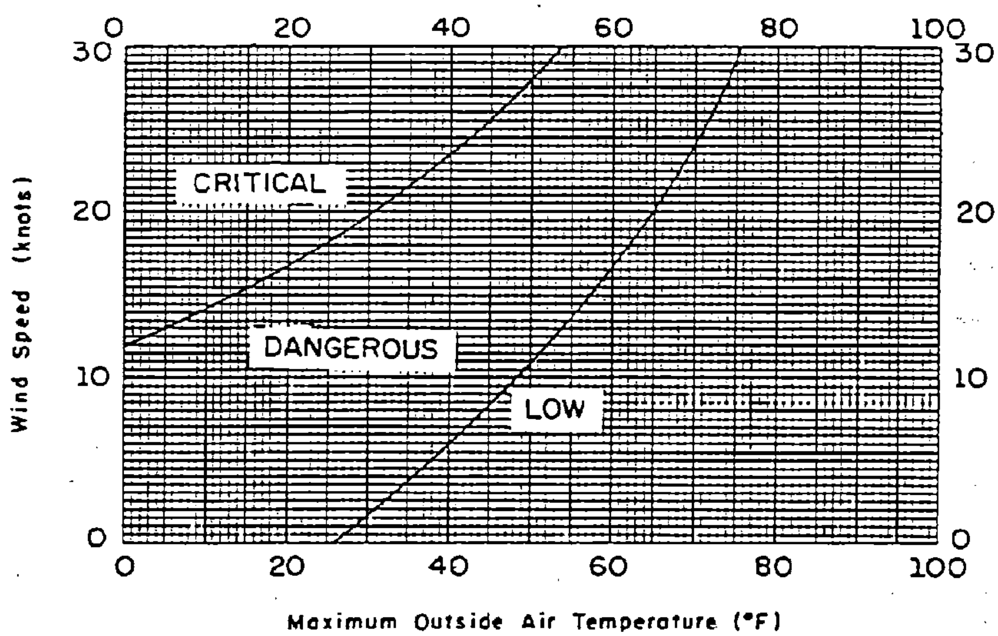

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Figure 3-18. Burning Potential for Urban Areas (Central Heating Being Used)

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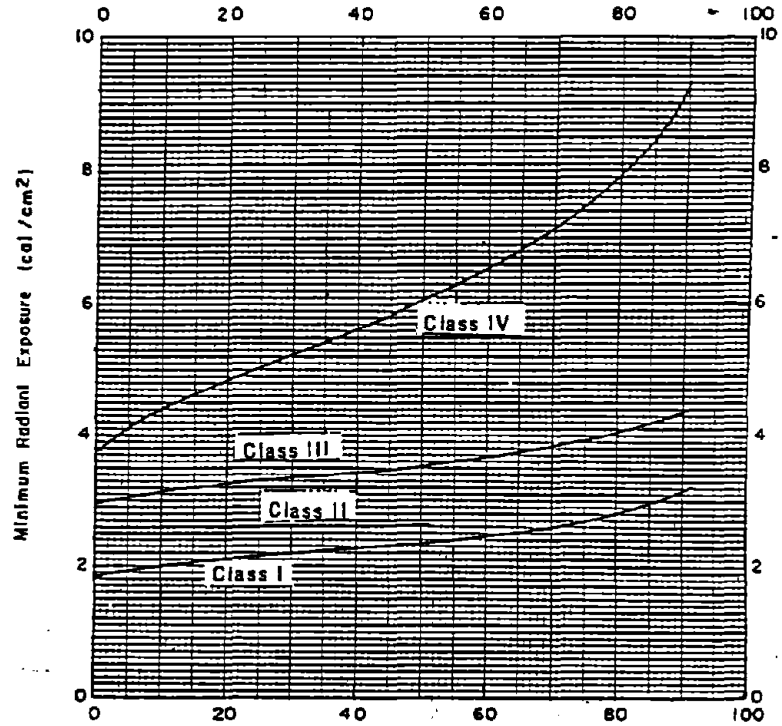

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Figure 3-17 Minimum Radiant Exposure for Ignition of Wildland Kindling Fuels by Class, Scaled to 1 KT

Note: Fires may be blown out by the blast wave, depending on the time interval between ignition and arrival of the shock. Blowout is not expected in overpressure regions below 5 psi for fully-exposed fuels.

TABLE XIV. BURNING POTENTIAL FOR WILDLAND FUELS DURING FIRE SEASON (TERRAIN WITH SLOPES LESS THAN 20%)

Wind speed at 20 feet above ground in the open	Relative humidity (percent)			
	Below 15	15-40	40-65	65-80
Below 5 knots	Dangerous	Dangerous	Low	Low
5-10 knots	Critical	Dangerous	Dangerous	Low
10-15 knots	Critical	Critical	Dangerous	Low
Above 15 knots	Critical	Critical	Critical	Dangerous

Definitions:

Low- irregular fire perimeter, spread greatly affected by local changes in fuel structure and topography, depth of fire small. Fire generally stops at roads and ridge tops. Control action can be on an individual basis.

Dangerous- continuous intense fire front which moves rapidly, frequently spots ahead. Aggressive organized action required to protect personnel and equipment.

Critical- conflagration-type fire, in heavy fuels readily crowns and spots as much as a mile ahead. Requires personnel and equipment to be evacuated from in front and from near the flanks of such fires. Control action effective only when changes in fuel type or burning conditions permit.

Note:
1. For heavy fuels, use the classification for the next higher wind speed.
2. For terrain with slopes greater than 20 percent, use the classification for the next higher wind speed.
3. For canopy shading 20 percent of the ground, reduce wind one class and increase relative humidity one class.
4. For full shading, reduce wind two classes and increase relative humidity two classes.

3-7 NEUTRON-INDUCED GAMMA ACTIVITY.

3-7.1 GENERAL. When weapons are detonated near the ground, neutron-induced gamma activity in the soil can result in dose rate levels of military importance near ground zero. Experimental data is not complete, and rigorous analytical predictions based upon a full knowledge of the fundamental phenomena can not be made in the present state of the art. The following factors which influence the level of neutron-induced gamma activity will be discussed and the available data presented:

Weapon Design will determine the flux and energy distribution of neutrons impinging on the ground near the point of burst;

Slant Range from burst point will also influence neutron flux and energy distribution;

Soil Composition will determine which elements susceptible to neutron activation may be present;

Decay and Dose Received from neutron-induced gamma activity are a function of time and the particular elemental soil constituents which were present for neutron activation.

3-7.2 NEUTRON-INDUCED GAMMA ACTIVITY CHARTS. Figures 3-31 through 3-34 enable the prediction of the dose rate at H + 1 hour at various slant ranges and for the special case at ground zero where slant range is equal to height of burst.

3-7.2.1 CHART SELECTION. Selection of the proper chart among figures 3-28 through 3-31 is made using the information contained in the chart title block. A general weapon type is described, and the mark designation of present stockpile weapons is given for each weapon. The charts are direct reading for most of the present stockpile yields, and other yields may be linearly interpolated between the yield curves plotted.

3-7.2.2 SELECTION AND USE OF SOIL TYPE FACTOR. The operational difficulty of obtained data on elemental soil composition and the extreme, very local, variation in soil compositions are probably the greatest sources of uncertainties in the prediction of neutron-induced radioactivity. Currently, available information is presented as it relates to four soil types. The illustrative soil types have been selected for their extremes of variation in contents of sodium, manganese, and aluminum, which are the elements having the greatest influence on the amount of neutron-induced contamination to be expected. Table XVI gives the composition of the four selected soil types. Elements are listed in descending order of importance to the neutron-induced radioactivity situation. Soil factors are presented for the four illustrative soil types, and these soil factors should be used directly if the soil in question is not of significantly different composition than one of the tabulated soil types. If the soil composition encountered is intermediate to the tabulated types, an interpolated soil fa will have to be estimated. The necessary use of an interme soil factor will further degrade the reliability of the resulti predicted dose rate. The dose rates read from figures 3-2 through 3-31 are multiplied by the soil factor to arrive at th dose rate expected on the soil in question.

3-7.2.3 SLANT RANGE AND CHART READING.

3-7.2.3.1 The charts are entered at the slant range of inter On the yield curve, read a dose rate and multiply this dose r by the appropriate soil factor.

3-7.2.3.2 If it is desired to find the slant range at which a specified dose rate may be expected, divide the specified do rate by the soil factor and enter the chart with the dose rate obtained. On the yield curve read out the desired slant rang

3-7.3 RELIABILITY. Dose rate values read from the curves ar corrected by a tabulated soil factor are correct within a fact of 5. For other soils where an estimated soil factor must b used, the data will merely furnish an estimate of the magnitu of the hazard.

3-7.4 REFERENCES. For additional data, refer to Capabilitie Atomic Weapons (U), TM 23-200, pages 4-65 through 4-71, ; Prediction of Neutron Induced Art in Soil, AFSWP-518.

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TABLE XVI.

SOIL MULTIPLYING FACTORS WITH CHEMICAL COMPOSITION OF ILLUSTRATIVE SOILS

	Soil type I (Liberia, Africa)	Soil type II (Nevada desert)	Soil type III (lava clay, Hawaii)	Soil type IV (beach sand, Pensacola, Fla)
MULTIPLYING FACTOR	0.11	1.0	12.0	0.002
ELEMENT *				
Sodium	---	1.30	0.16	0.001
Manganese	0.008	0.04	2.94	---
Aluminum	7.89	6.90	18.79	0.006
Iron	3.75	2.20	10.64	0.005
Silicon	33.10	32.00	10.23	46.65
Titanium	0.39	0.27	1.26	0.004
Calcium	0.08	2.40	0.45	---
Potassium	---	2.70	0.88	---
Hydrogen	0.39	0.70	0.94	0.001
Boron	---	---	---	0.001
Nitrogen	0.065	---	0.26	---
Sulfur	0.07	0.03	0.26	---
Magnesium	0.05	0.60	0.34	---
Chromium	---	---	0.04	---
Phosphorus	0.008	0.04	0.13	---
Carbon	3.87	---	9.36	---
Oxygen	50.33	50.82	43.32	53.332

* Elements are given in percentage by weight for the various type soils.

3-8 DECAY OF NEUTRON-INDUCED RADIOACTIVITY.

3-8.1 GENERAL. The decay of neutron-induced gamma activity must be considered as a function of soil composition as well as time. The effect of these variables is as described in paragraph 3-7.

3-8.2 NEUTRON-INDUCED RADIOACTIVITY COMPUTATIONS.

3-8.2.1 Enter the Neutron-Induced Radioactivity Decay Factor Chart, figure 3-35 with the time, t, after detonation in hours and read the decay factor on the curve for the proper soil type. This factor is multiplied times the H + 1 hour dose rate to obtain the dose rate at time, t, in hours.

$$DR_{H+t} = DR_{H+1} \times DF_{H+t}$$

3-8.2.2 If the dose rate at any time is known, and the reference dose rate at H + 1 hour is desired for a radiological situation map, the formula is

$$DR_{H+1} = DR_{H+t}/DF_{H+t}$$

3-8.3 RELIABILITY AND REFERENCES. Reliability and references are the same as given in paragraphs 3-7.3 and 3-7.4.

3-8.4 ILLUSTRATIVE EXAMPLE.

1. *GIVEN*

An area having type I soil had an H + 1 hour dose rate of neutron-induced gamma activity of 80 r/hr.

2. *REQUIREMENTS:*

Estimate the dose rate at H + 4 hours.

3. *SOLUTION:*

a. Enter figure 3-35 at a time after detonation of 4 hours and read on the Soil Type I curve and on the right vertical scale a decay factor of 0.4.

b. $DR_{H+t} = DR_{H+1} \times DF_{H+t}$.

c. $DR_{H+4} = 80 \times 0.4 = 32$ r/hr.

4. *ANSWER:*

The neutron-induced gamma dose rate at H + 4 hours may be expected to be about 32 r/hr.

3-9 RADIATON DOSAGE RECEIVED IN AN AREA OF NEUTRON-INDUCED RADIOACTIVITY.

3-9.1 GENERAL. The total radiation dosage and the resultant injury sustained by personnel in a radiation field is the operational answer desired. Also, a commander may announce a maximum allowable, probably non-injurious, dose which is not to be exceeded by personnel whose battlefield duties require some exposure to residual radiation. Since a field of residual radiation is continuously decaying in a known relationship to the passage of time, the dosage received during exposure to the radiation field may be reduced by shortening the period of exposure or by deferring entry into the field until additional radioactive decay has occurred. Both a shorter time of stay or a later time of entry may be necessary to hold the total dosage to an acceptable level.

3-9.2 INSTRUCTIONS FOR USE OF DOSAGE CHARTS.

3-9.2.1 The decay of neutron-induced radioactivity is dependent upon soil composition as discussed in paragraph 3-7, hence the data for estimation of radiation dosage is also presented for the four soil types in figures 3-36 to 3-39.

3-9.2.2 A selection of soil type and the appropriate figure is made employing the guidance of paragraph 3-7. The calculation involving total residual radiation dose involves four parameters. If any three of these are known, the fourth may be calculated:

TE = the time of entry into the contaminated area.

TS = the time of stay in the contaminated area.

DR_{H+1} = the dose rate in the contaminated area at H + 1 hour (one hour after detonation).

TD = the total dose received.

Figures 3-34 to 3-39 plot TE, TS, and a multiplying factor MF,

$$MF = TD/DR_{H+1}, \text{ or}$$
$$TD = MF \times DR_{H+1}$$

3-9.2.3 Instructions for the use of the neutron-induced radiatic total dose charts are given in table XX, page 142.

3-9.3 RELIABILITY AND REFERENCES. Same as given in paragraph 3-7.3 and 3-7.4.

3-9.4 ILLUSTRATIVE EXAMPLE.

1. *GIVEN:*

The dose rate in a neutron-induced area of gamma radiation is measured to be 125 r/hr. The soil is type I.

2. *REQUIREMENT:*

a. Personnel must occupy this area for 3 hours without exceeding a total dose of 25 r. When can they enter the area?

b. If personnel must enter this area 2 hours after detonation, how long can they stay in the contaminated area without exceeding a total dose of 50 r?

c. What total dose would personnel receive if they enter this area 7 hours after detonation and remained for 10 hours?

3. *SOLUTIONS:*

a. *SOLUTION TO REQUIREMENT a.*

STEP 1: $DR_{H+1} = 125$ r/hr, TS = 3 hours, TD = 25 r: calculate $MF = TD/DR_{H+1} = 25/125 = 0.2$.

STEP 2: Enter figure 3-36 on left vertical axis with MF = 0.2; read right to intersection with 3 hour TS curve.

STEP 3: At this intersection, read down to time of entry of 9.5 hours.

b. *SOLUTION TO REQUIREMENT b.*

STEP 1: $DR_{H+1} = 125$ r/hr, TE = 2 hours, TD = 50 r: calculate $MF = TD/DR_{H+1} = 50/125 = 0.4$.

STEP 2: Enter figure 3-36 on left vertical axis with MF = 0.4; enter on bottom axis at TE = 2 hours.

STEP 3: The point of intersection is at about half the distance between TS curves 0.3 and 1.0 hours. However, when the distances to the 0.1 and 3.0 hour curves are noted it appears that the point of intersection should be interpolated as being about 0.5 hour time of stay.

c. *SOLUTION TO REQUIREMENT c.*

STEP 1: $DR_{H+1} = 125$ r/hr, TE = 7 hours, TS = 10.

STEP 2: Enter figure 3-36 with TE = 7 hours on bottom axis; read up to intersection with TS = 10 hour curve; read left to vertical axis and read MF = 0.66.

STEP 3: Calculate $TD = MF \times DR_{H+1} = 0.66 \times 125 = 82.5$ r.

4. *ANSWER:*

a. Time of entry, TE = 9.5 hours.
b. Time of stay, TS = 0.5 hours.
c. Total dose, TD = 82.5 r.

NOTE: Note that requirements are separate problems and the answers are not related.

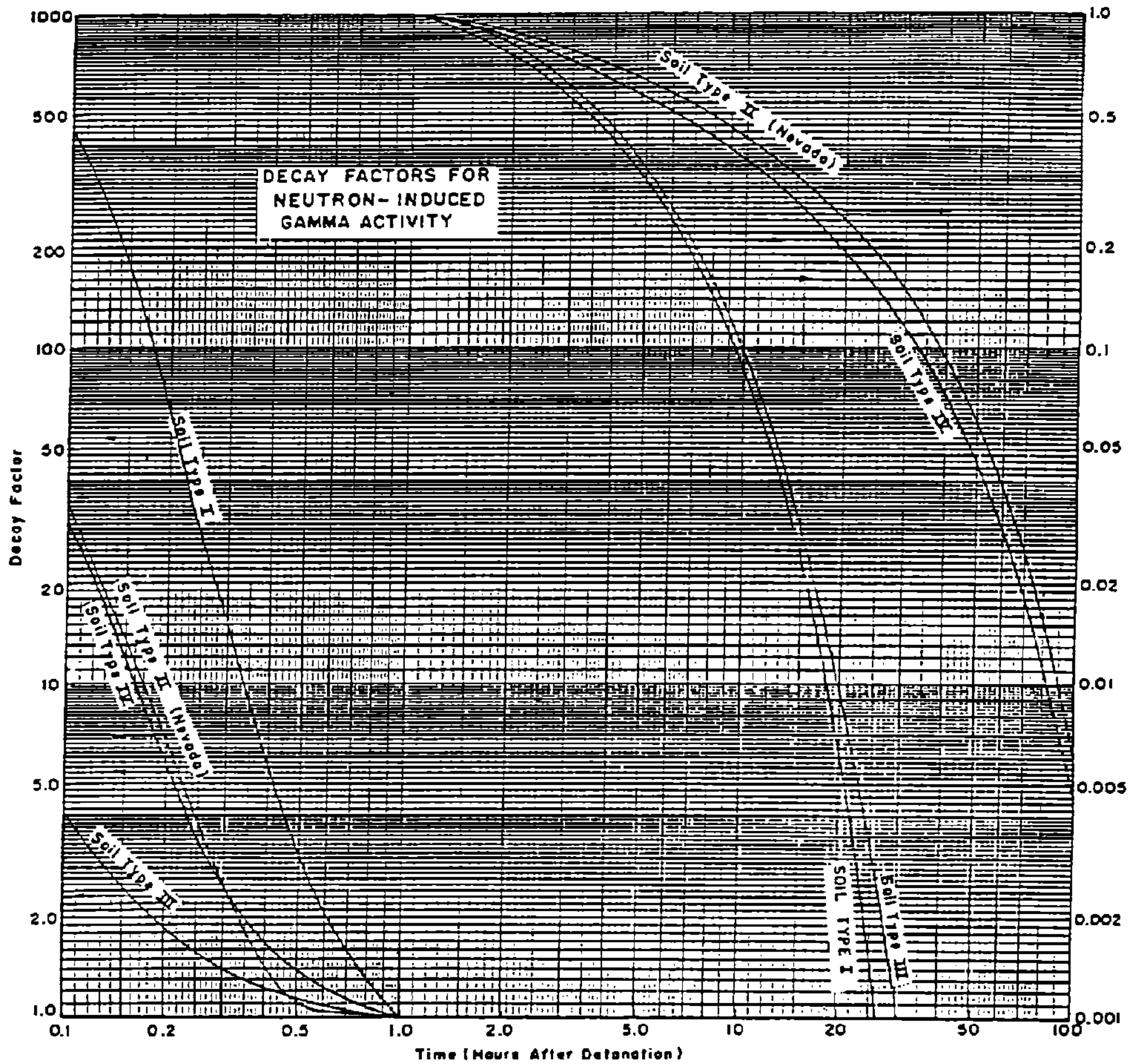

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Figure 3-35

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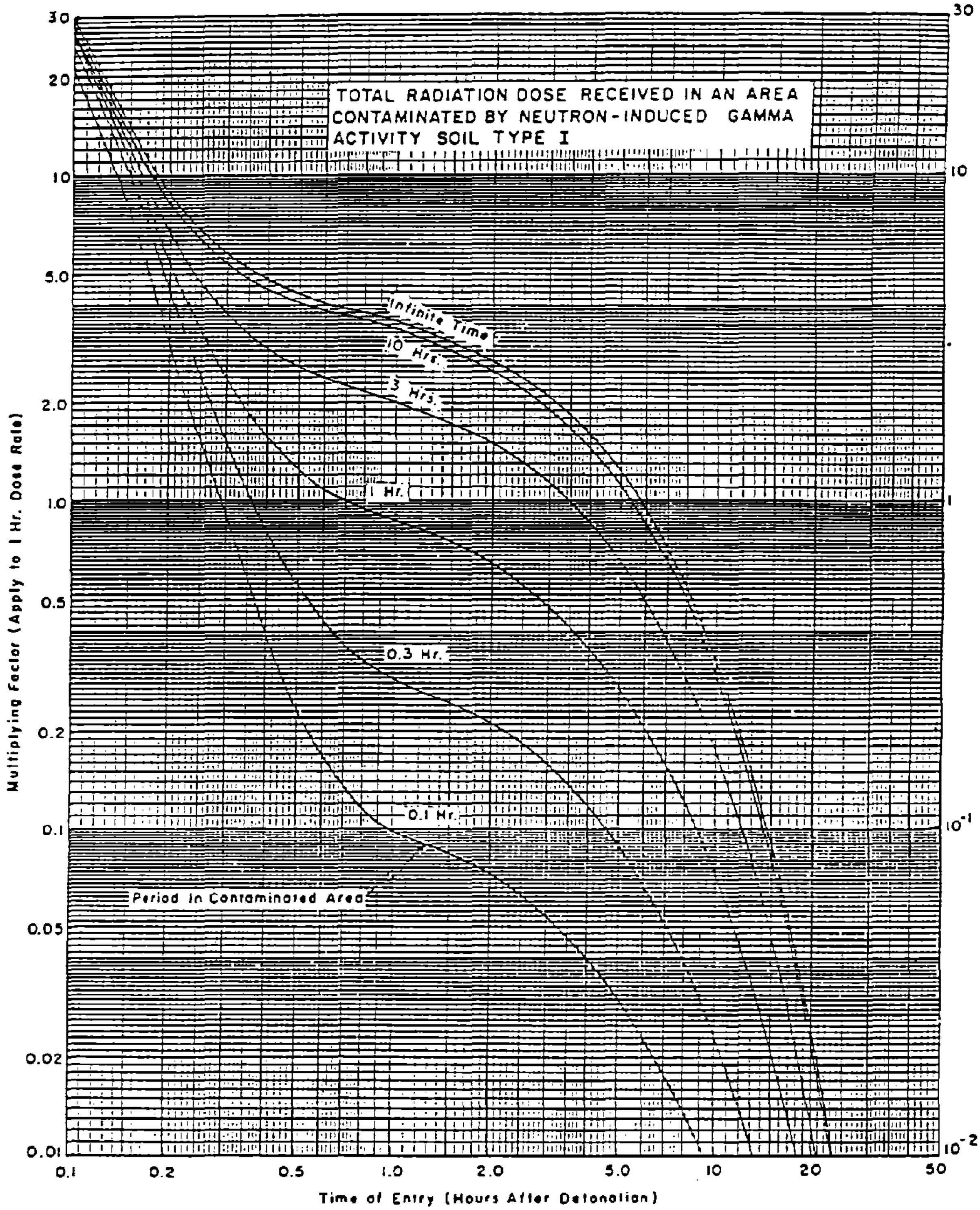

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Figure 3-36

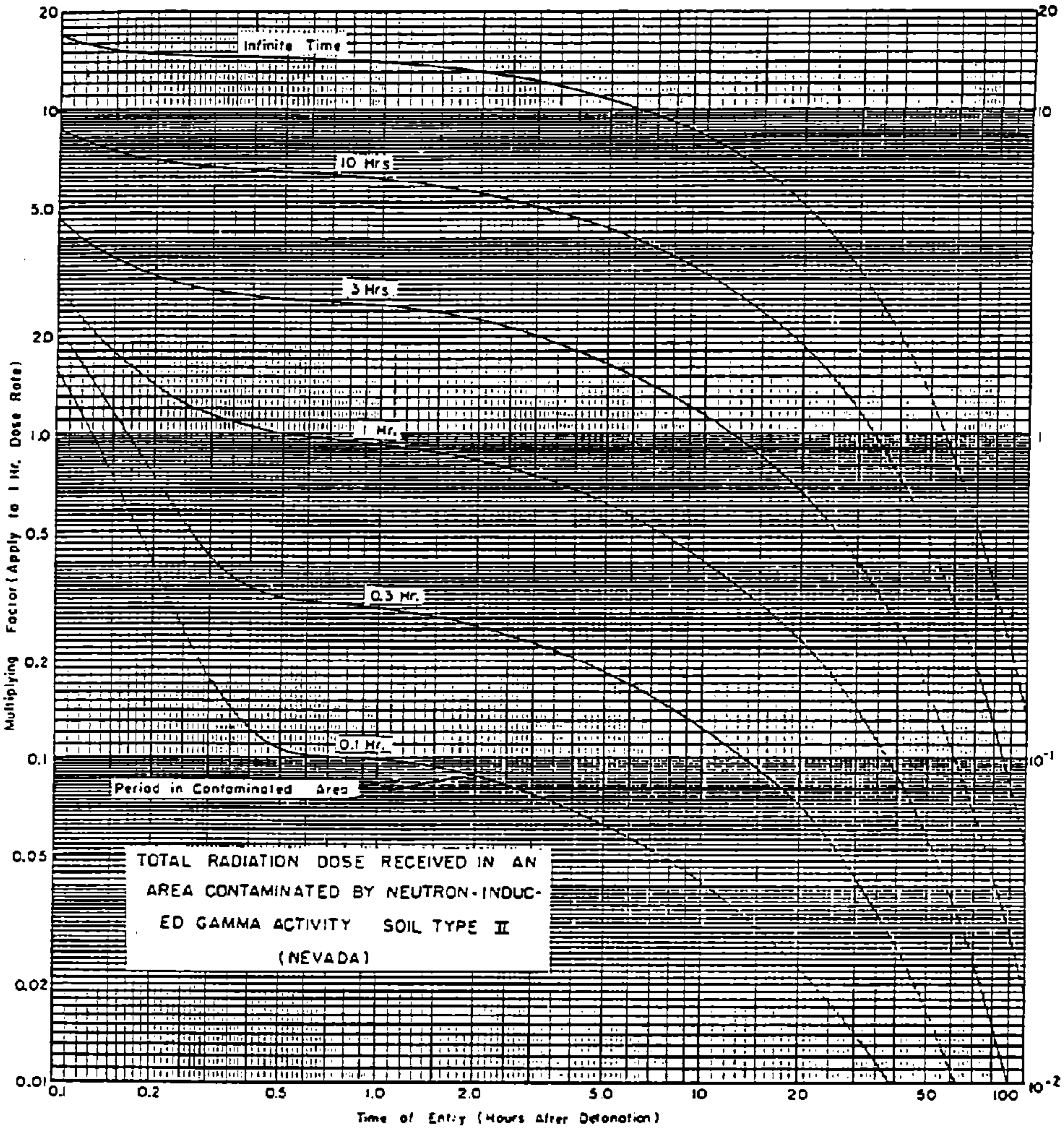

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Figure 3-37

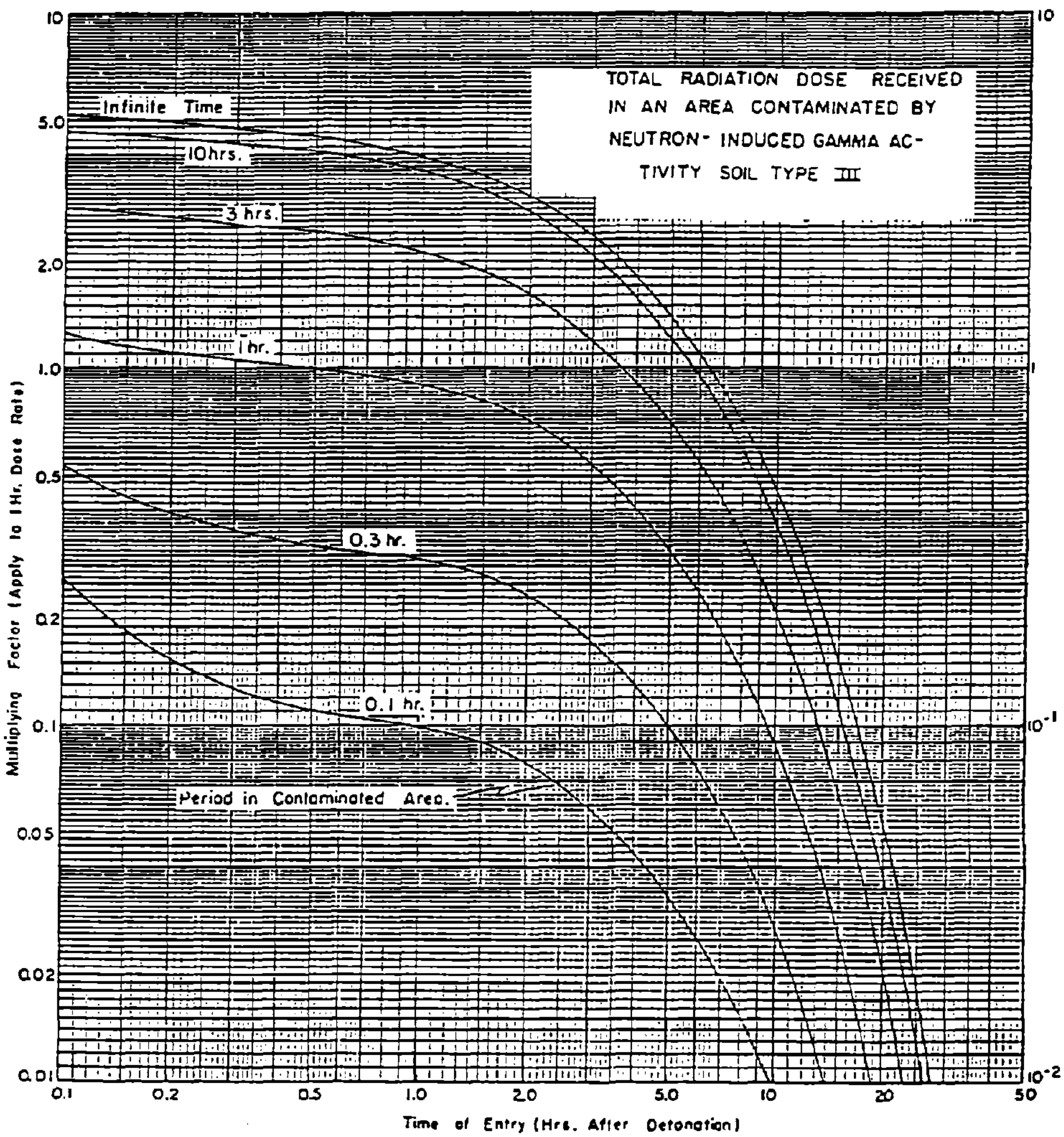

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Figure 3-38

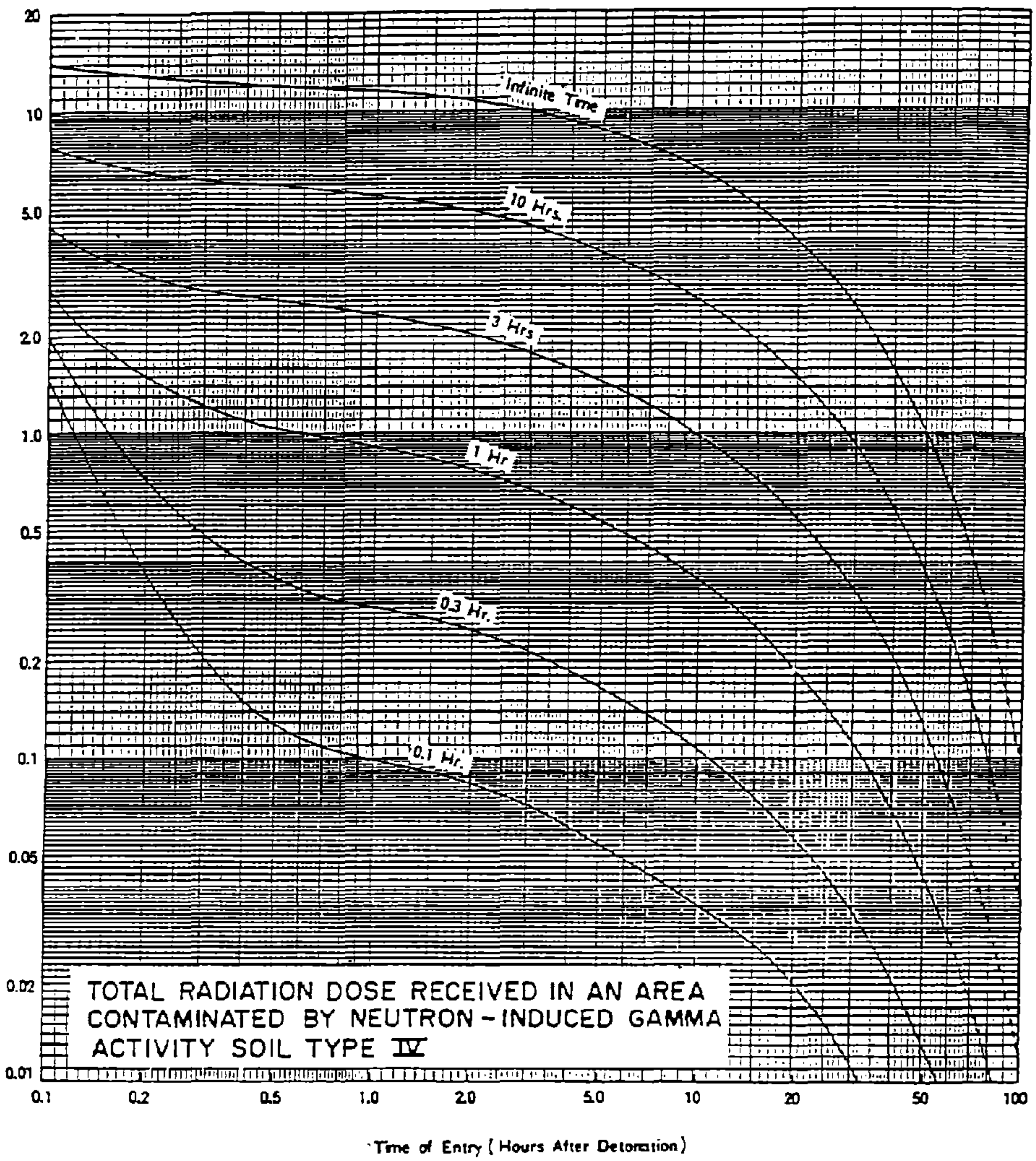

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Figure 3-39

SECTION 6

OPERATIONAL CONSIDERATIONS

6-1 GENERAL. The purpose of this section is to assist the analyst in completely evaluating all that will happen to the area within and surrounding a target complex. This section consists of troop safety, equipment safety, and effects analysis. It should be remembered that the solution from the Sandia Method is based upon the targets the commander desires destroyed. With a selected yield, H_B, and RGZ, the analyst attains an acceptable assurance of damaging these assigned targets in the complex. This selected yield, H_B, and RGZ, will also do damage to other objects near the targets or target complex. The analyst should have complete answers as to where and to what extent this additional damage will occur as well as objects that will suffer no damage.

6-2 TROOP SAFETY.

6-2.1 The purpose of the troop-safety calculations presented is to establish some minimum safe distance (MSD) from the reccommended ground zero (RGZ) to the nearest friendly unit such that no friendly-troop casualties will result. A recommended ground zero (RGZ) closer to friendly troops than the MSD will not be selected unless significant advantages will accrue. The method of troop-safety calculation deals only with the effects that occur at the time of detonation. Other effects will be considered later in Effects Analysis, (paragraph 6-6).

6-2.2 The minimum safe distance (MSD) is the sum of a safety radius (R_S), which takes into consideration the maximum effects from the weapon detonation, plus a buffer distance (d_b), which takes into consideration the maximum errors of the delivery system employed and the disposition of the friendly units.

6-2.3 The safety radius (R_S) is obtained from safety-radius curves. These are direct-reading curves which give a distance from the ground zero at which no casualties or no damage may be expected.

6-2.4 The safety-radius curves do not take into consideration all of the factors associated with troop-safety problems. Many factors have too limited an application while other factors are too intangible to pinpoint specifically. Factors that are not included, but should be considered when performing troop-safety calculations, are: missile hazards created by the presence of wooded areas, buildings, vehicles, or equipment; eye injury to troops in the open (either temporary flash blindness, permanent or semipermanent injury due to burns on the retina); fires, both primary and secondary which may involve friendly positions; and the cumulative effect on troops of prior or subsequent exposures to nuclear radiation.

6-3 SAFETY-RADIUS CURVES FOR TROOPS IN THE OPEN.

6-3.1 The safety-radius curves for troops in the open, figures 6-3 and 6-4, are based on effects levels which were taken as the threshold values for casualty production from initial nuclear radiation, thermal radiation, and blast. The criteria selected are:

1. Thermal radiation, a threshold energy for 1st degree burns to exposed skin of 2 calories per square centimeter (2 cal/cm^2) for 1 KT and scaled to the appropriate yield.

2. Nuclear radiation, 10 roentgens equivalent mammal (10 rem) from initial gamma and neutrons for a relative air density of 0.9.

3. Blast, 0.01 probability of causing casualties due to translational motion. In no instance was the blast criterion the decisive consideration, since the hazard due to 2 cal/cm^2 (1 KT equivalent) or 10 rem extends much farther.

6-4 SAFETY-RADIUS CURVES FOR TROOPS IN FOXHOLES - WARNED.

6-4.1 For the safety-radius curves for warned troops in foxholes, figures 6-5 and 6-6, the troops are assumed to be in foxholes which are at least as deep as the height of the individual. It is further assumed that at the time of the detonation the individual will be in a crouched position in the foxhole so that the uppermost portion of his body will be at least 2 feet below the top of the foxhole. Assuming a 2-foot width for the foxhole, this would mean that for angles of incidence greater than 45 degrees from the vertical, no direct radiation either thermal or nuclear, would be received by the individual in the foxhole.

6-4.3 An attenuation factor of 0.1 was assumed for initial gamma radiation and 0.3 for neutron radiation. The nuclear-radiation criterion was 10 rem received in the foxhole for a relative air density of 0.9. The criterion of 10 rem received in the foxhole was the dominant consideration

6-4.4 At the safety-radius distances involved, the static overpressure is 5 psi and there is about a 10 percent probability of foxhole collapse. According to the best available information, negligible blast casualties would occur under these circumstances.

6-5 EQUIPMENT SAFETY.

6-5.1 GENERAL. The method for determining equipment safety is similar to troop safety; i.e., the minimum safe distance (MSD) is obtained by adding the radius of safety (R_S) to a buffer distance (d_b).

6-5.2 EQUIPMENT SAFETY-RADIUS CURVES.

6-5.2.1 Light-damage curves are incorporated for the purpose of obtaining the radius of safety desired, depending on the criteria established by the commander.